

UNIVERSITY OF CALIFORNIA

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Experiments on Methods of Fermentation.

In view of the great interest attaching to the determination of the effect of various methods of fermentation upon the resulting wines, a series of experiments with one and the same kind of grape, treated differently both in respect to temperature and the appliances used, was carried out at the Viticultural Laboratory with the results given below.

These experiments were all conducted within the limits of temperature adapted to "high fermentation," since the question of how best to manage the fermentation at the prevailing vintage temperature of California is the one having the greatest practical interest. As no means were at hand for maintaining a temperature sufficiently low for "low fermentations," proper, these were omitted, but it is intended to arrange for such experiments next season.

It should be distinctly understood that these few experiments were selected from the large number of possible ones, in order to test the influence of certain conditions upon the composition and quality of red wines, so as to deduce therefrom principles that shall apply to large as well as small-scale practice, when allowance is made for the known difference of circumstances in each case.

The grapes used are a very good article of second-crop Zinfandel, courteously donated by Mr. J. Gallegos, of Mission San Jose. About one and one-sixth tons were sent, in University basket crates. They arrived in excellent condition; the berries were rather small and the bunches quite loose, but thoroughly sound; taste agreeably sweet, and juice abundant. The composition of the latter was as follows:

Solid contents by spindle.....	21.05
Sugar by copper test.....	19.75
Acid.....	.65
Ash.....	.27

Nine different samples were fermented, under the following conditions:

(A.) In a hot chamber kept at a temperature ranging from 98 degrees to 102 degrees, two batches of about 63 pounds each; one (No. 557) left entirely open in the tub; the other (No. 556) covered with a "floating top" that rose and fell with the pomace, screening it from access of air. Both were subjected to "foulage" or stirring.

(B.) In a room kept at a temperature ranging from 72 degrees to 75 degrees: five 50-gallon tanks, each charged with about 230 pounds, nearly filling the tanks, and arranged as follows:

No. 558. Mash put in in three successive portions, kept separate by a lattice framework wedged in place, thus forcibly keeping the pomace submerged and divided into three separate portions—according to Perret's system; the uppermost frame being about two inches below the surface of the must before fermentation. Tank covered.

No. 559. Mash put in at once and the pomace kept submerged about two inches by means of a single Perret's frame, as practiced to some extent at Fresno and elsewhere; no cover.

No. 560. Mash left uncovered and subjected to frequent "foulage" or stirring, at least three times a day, during fermentation; a common French and Californian practice.

No. 561. Mash covered with a "floating cover," rising and falling with the pomace, any froth on upper side being washed off; stirred three times a day; a French method, and adopted at the Viticultural Laboratory.

No. 563. Grapes put in whole, stems and all, to be gradually crushed by means of a cross-peg stirrer, used energetically three times a day; no cover. A Burgundy method, used at several California wineries; known as "Morel process."

No. 564. A tub charged with about 140 pounds of mash, and then left to itself, cap, vinegar-flies and all; without stirring or cover; the old Californian, or "go-as-you-please," method.

(C.) In the cellar of the laboratory kept at a steady temperature of 62 degrees.

No. 562. Fifty-gallon tank charged like the rest with 230 pounds of grape mash, provided with a "floating cover," and stirred three times daily.

In all cases the temperature was ascertained thrice daily; during the height of fermentation every few hours; and in the tanks provided with frames the temperature of the top liquid, and of the pomace beneath each frame, was taken separately, in order to follow the exact course of fermentation. Similar observations were made every morning in the tanks subjected to stirring, so as to ascertain the temperature of the top and bottom layers of the pomace cap formed during the night, and that of the liquid beneath.

The details of the fermentations, however instructive, are too lengthy to be given in this place, and will be found fully recorded in the forthcoming report for the year 1886. It need only be said that while No. 556, fermenting at 100°, went dry within 48 hours, No. 562, at 62°, required ten days. Of the rest, No. 560, the open tank subjected to frequent stirring, went through most rapidly and energetically.

Composition of the Wines.

The table below shows the composition of the wines resulting from the several fermentations. They were all analyzed, and their color determined, within a few days after pressing, the mark being filtered for the purpose.

Composition of Wines Produced by Different Methods of Fermentation.

Number.	SAMPLE.	WINE.				
		Alcohol.	Acid as Tartaric.	Tannin.	Intensity.	Color.
		By Weight.	By Volume.			Tint.
556	Foulage, with floating cover....	7.78	.49	14.45	.2d	purple-red
557	Foulage, without cover.....	7.78	.59	13.42	.2d	purple-red
558	Three Perret's Frames.....	7.78	.49	10.30	.2d	purple-red
559	Single Perret Frame.....	7.78	.51	10.27	.8	purple-red
560	Foulage, no cover.....	7.23	.65	10.46	.2d	purple-red
561	Foulage, with floating top....	7.78	.53	12.47	.0	purple-red
562	Morel Process.....	7.16	.67	13.47	.6	purple-red
563	Old style, no cover nor foulage.)	7.09	.85	12.46	.6	purple-red
564	Foulage and floating top, Temp. 62°.....	7.78	.56	12.34	1	purple-red
		(7.78	.56	12.34	1	purple-red

is accompanied by its transformation into vinegar is apparent to the nostrils so soon as the first violent stage of the fermentation is past.

In the case of the "Morel process," the cause of the loss of alcohol is not so obvious. It must be partially accounted for by the abundant stirring and high temperature; but it is possible that from some cause a part of the sugar may have been converted into some other compound than alcohol.

A somewhat unexpected result is the fact that the two hot fermentations (556 and 557) yielded the same amount of alcohol as those fermented at a much lower temperature. The obvious explanation is, that the short duration of these fermentations balanced the influence of the high temperature as compared with those in the slower fermentations, in which the opportunity for evaporation lasted longer. It will be highly interesting to compare, hereafter, the other products formed alongside of the alcohol in the three sets of fermentations.

As regards, next, the *acid* of the several wines, it is not unexpected to find that the open *foulage*, No. 560, on the one hand, and the Morel process on the other, have given the highest figures; the one because of the constant access of air, the other from the same cause, in addition to the extraction of acid from the stems.

The lowest figure for acid (.49) is given by Nos. 556 and 558, the hot fermentation with cover, and by the one with the three submerged frames. In the case of the latter this was to be looked for, and is precisely one of the chief advantages claimed for Perret's method. In the case of the former it is somewhat unexpected, and is the more instructive in contrast to No. 557, the hot fermentation in which no cover was used, and in which the acid is one pro-mille higher. Almost precisely the same difference occurs in the fermentations made at the lower temperature, one with the floating cover on (No. 561), and the other (No. 560) without cover. The beneficial influence of the cover in preventing the formation of acid during fermentation is therefore placed beyond question.

It should, however, be added, that in none of the fermentations made, there is at this time (Nov. 24) a notable amount of volatile (acetic) acid. This is true even of No. 564, the "old-style" one, in which the odor of vinegar was abundantly obvious before pressing. It shows the odor of vinegar plainly in boiling, but the amount is at present less than five thousandths of one per cent.

It is somewhat remarkable that the fermentation No. 562, made at the lowest temperature, should yield a relatively high proportion of acid, exceeding that found in the fermentation made under the same conditions at a higher temperature. Whether this is to be accounted for by the longer duration of the low-temperature fermentation, remains to be investigated.

As regards, first, the *alcoholic contents* of the several wines, it will be noted that the same percentage was obtained in six out of the nine; while three, viz., Nos. 559, 563 and 564, corresponding respectively to the single-frame, Morel, and "old-style" processes, show a deficiency which does not differ widely for the three, being not quite one per cent.

In the single-frame process, a relatively thin layer of liquid was exposed to the air, constantly agitated by the gas coming from below, and heated by its position just over the hot cap. The alcohol simply evaporated from this isolated portion of the wine, and [where this mode of fermentation is practiced on the large scale I have sometimes found this layer so warm that toward the end of the fermentation the bulk of its alcohol was gone and it had a vapid, flat taste, often more of vinegar than of alcohol.

In the case of the old-style process, also, it is easy to see where the loss of alcohol occurs. It is here the hot pomace cap, offering a large surface to the air and kept drenched with the fermenting liquid by the bubbling up from below, which assists the evaporation. That the latter

Considering, next, the matter of *tannin*, we note at a glance the influence of the high temperature in aiding a complete extraction. The two hot fermentations, Nos. 556 and 557, have given the maximum of tannin, despite their short duration; more even than in the case of the tank with diligent open *fouillage*, and as much as the Morel process, stems and all, which was continued for 11 days; the effect in this case is so marked as to leave no doubt of the influence of this factor, and in it lies, probably, at least a part of the explanation of the fact that the hot parts of our State have yielded more tannin in their red wines than the cooler ones.

The two tanks in which the frames were used (Nos. 558 and 559) present a curious problem. In both cases the same amount of tannin was taken up, although in the one the pomace was in a solid mass, and in the other was kept diffused all through. The result is disappointing as concerns the three-frame process, and shows clearly why, despite its apparent advantages, this method of treatment has not been widely adopted, even in France. It is evident that simply keeping the pomace in the liquid cannot replace the grinding and disintegrating action of the direct stirring or *fouillage*, so far as the extraction of tannin and color are concerned; for a glance at the color column shows that the deficiency of tannin is accompanied by a similar relative deficiency of color, as compared with the tanks that were stirred. The same holds of the single-frame fermentation, where the color is even less; and the fact that an even amount of tannin was extracted, notwithstanding the pomace was in a solid mass at the top, is explained by the high temperature which, as the record shows, prevailed in that cap. The same consideration doubtless applies to the "old-style" (No. 562), in which the high temperature of the pomace cap offset the lack of stirring, and both tannin and color were fully extracted.

A singular and unexplained fact is the deficiency of tannin in the tank with open *fouillage*, without cover, for which no obvious cause can be assigned; the duplication of the determination, however, leaves no doubt of the fact, which can hardly be explained without assuming that some of the tannin at first extracted was subsequently destroyed by the action of the air. If this were so, the full complement of tannin in the "Morel" product might be explained by the presence of the astringent stems.

The column giving the color-intensities is very instructive also. It will be seen that those yielding a low color were the two tanks with frames, already discussed, and the low-temperature fermentation, No. 562, in which, despite

diligent stirring, and the pretty full extraction of tannin, that of the color remained incomplete, being nearly one-third less than the maximum.

The full discussion of the bearings of these fermentation experiments is perhaps best deferred until the development of the wines, and their full analysis in their more advanced condition, shall give more data in regard to the final results of the several treatments. Those familiar with the subject of fermentation may, however, already derive important lessons from what is recorded above. Of course, these results must be verified by repetition the coming season, before they can be accepted as maxims; but there is much that cannot well be upset by any subsequent experiments. Among the points that may be considered well settled is that the method of fermentation adopted by this department (viz.: floating cover, with thrice daily stirring,) is amply justified by the outcome of the nine fermentations. It secures all the advantages of aeration, full extraction of tannin and color, and maximum of alcohol, without any risk of acetification if properly managed. The method has been carried out on the large scale by Mr. John Gallegos for two years past, and has yielded excellent results; the only difficulty encountered being that in the case of very soft-skinned grapes, the frequent stirring reduced them to a pulp which it was difficult to press. In such cases the stirring must be moderated and made with implements having the least crushing effect; but I am satisfied that in the hot vintage climate of California, the leaving-open of fermenting tanks to the access of air is most objectionable, is one of the most common and prominent causes of unsoundness, and should be done away with universally, adopting either the use of floating covers, or at least a cover over the top of the tank. Whether the disadvantages of the single-frame system can be overcome by a repeated pumping-over of the liquid from below over the pomace, is a question yet to be determined; but that in the use of this method there is always a serious loss of color and tannin, can hardly be doubtful.

Regarding the quality of the wines resulting from the several processes, but little can as yet be definitely said. However, the unanimous verdict of those who have thus far tasted them is to the effect that the product fermented at 62°, though light-colored, is the best, and that rushed through within 48 hours beyond comparison the poorest, being flat and without character. Time alone, however, can definitely determine the ultimate outcome.

E. W. HILGARD.

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